Sneak Current Paths Generated by the Activation of a Squib Device

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The deployment of mechanical systems in space flight is often accomplished with pyrotechnic devices. The activation element of a pyrotechnic device is a squib, such as the NASA Standard Initiator (NSI). In a typical squib activation process, a high current (~20 A) is applied to the bridge wire inside the device. The bridge wire then heats up the explosive materials within the device. The bridge wire is eventually disrupted by the force of the explosion. The entire process is a fast transient event (< 1 ms) and electromagnetic interference (EMI) are generated by the turn on/off of the current to the bridge wire. To avoid coupling of pyro-generated EMI to sensitive circuits, the wires in the squib initialing circuit are usually shielded and twisted. However, even with standard EMI design fully implemented in the pyro-activation circuits, anomalies that could be attributed to the pyro generated EMI were still experienced on space flights. An example is the Magellan computer anomaly (corruption of 4 Kbytes of memory) which occurred during the separation of the solid rocket motor casting by the activation of six NSI devices (3 separation nuts).

Recent analysis and ground test results have indicated that during the activation of a squib device, the ionized material (plasma) within the squib device can form a conductive path between the! power supply and the chassis of the squib device. Since the chassis of the squib device is connected to spacecraft structure, a short circuit between the power supply and spacecraft structure results. This short circuit enables the spacecraft structure to be a sneak path for the transient current resulting from the activation of a squib device. This sneak current path acts as a source of EMI and can cause noise to be induced in circuits. The signal that can be induced depends on the topologies of the sneak current path and the cable layout . These topologies will affect the coupling mechanisms. Using the actual cable configuration for the

Magellan spacecraft, an analysis indicated transient signals of order of 1 () volts could be induced on the victims circuits leading to the memory device. 'l'his analysis confirms the hypothesis that the pyro generated 1 :MI was the cause of Magellan memory anomaly.

in this paper, the physical mechanisms that are responsible for the formation of short in a squib device will be presented. The topology of the sneak current paths generated by the resulting short, and methods to minimize the adverse effects of the sneak current paths will also be discussed. The paper will be illustrated with several case studies which include the Magellan, Galileo and Mars observer missions.

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